National Aeronautics
and Space Administration

2015
ANNUAL REPORT

NASA Earth Science
Applied Sciences Program

FROM THE DIRECTOR

Lawrence Friedl, Applied Sciences Program

Drought management, earthquake recovery, air quality planning, river blindness eradication, reverse auctions, rapid wildfire rehabilitation, and bird migration. All these and more were ways that our partners used Earth observations to support their activities in 2015—and all are part of our annual report. Truly, it was a successful year. This report captures just a few examples of how Earth observations informed decisions and benefited society. Much more is on our redesigned website, which we launched in, you guessed it, 2015.

All three lines of business—Applications, Capacity Building, and Satellite Mission Support—had a strong year. We added new projects to our applications portfolio. Our ARSET training program reached people in every U.S. State and 123 countries. And we held more than 11 satellite mission events on the applications they'll support, such as workshops for *ICESat-2*, *CYGNSS*, and *GPM*.

We became heavily involved in some global initiatives as well. Among others, we'll be encouraging the use of Earth observations as part of the 2015–2030 UN sustainable development goals and we'll help organize data sharing in the Americas.

We hope you explore this report and discover how our partners are using Earth science data in practical and innovative ways. And, if it sparks ideas for how you and your organization can use Earth observations, please contact us.

WHAT'S APPLIED SCIENCES?

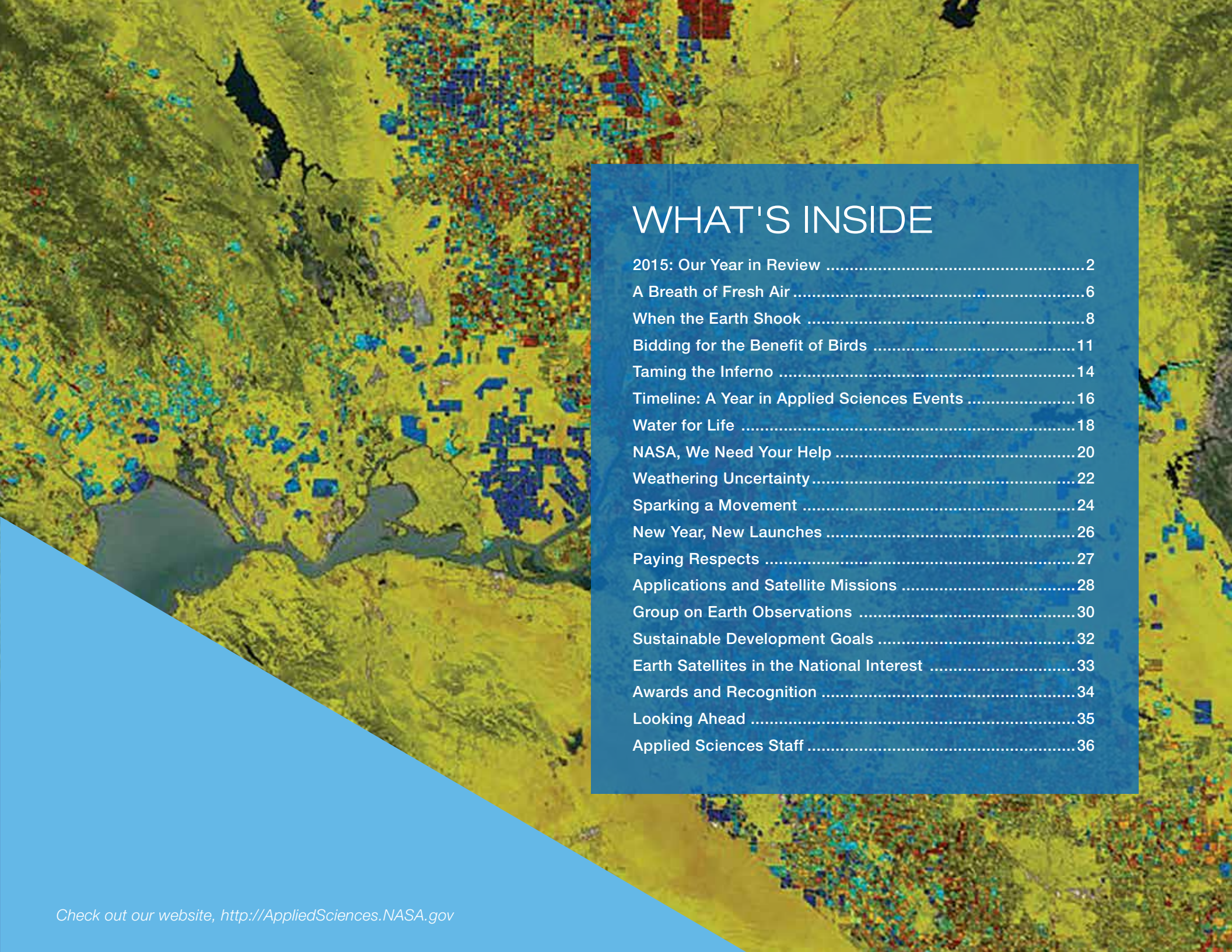
The Applied Sciences Program promotes efforts to discover and demonstrate innovative and practical uses of Earth science data and knowledge. We support applied research and applications projects that enable ways for organizations to apply data from Earth-observing environmental satellites to inform their decisions and actions.

All our activities support goals to deliver near-term uses of Earth observations, build capabilities to apply Earth science data, and contribute to satellite mission planning. We carry out all of our projects in partnership with public and private sector organizations to enable sustained use and sustained benefits.

We have three lines of business: Applications, Capacity Building, and Satellite Mission Planning. Our Applications areas address disasters, ecological forecasting, health and air quality, water resources, and wildfires. Capacity Building works with users in the U.S. and developing countries to improve skills and workforce by applying Earth observations. Satellite Mission Planning engages users to envision potential applications for future Earth-observing satellites, helping them prepare to use the data and further enhance the value of each satellite mission.

We'll continue to pursue new opportunities and effective ways for NASA Earth Science to serve society and benefit all humankind.

The Applied Sciences Program is part of the Earth Science Division of the NASA Science Mission Directorate.



WHAT'S INSIDE

Check out our website, http://AppliedSciences.NASA.gov

2015: OUR YEAR IN REVIEW

The Applied Sciences Program had a strong year in 2015. In fact, we surpassed our performance target. Overall, we served our goals of delivering near-term uses of Earth observations, building capabilities to apply Earth science data, and contributing to satellite mission planning.

Applications Areas

The applications areas had another highly productive year, nurturing their existing projects, actively working with partners, and identifying new projects to pursue. Pages 6-25 feature some projects, and here are some key activities from the year:

The Water Resources area tracked eight projects focusing on drought, and nine addressing seasonal outlooks of water supply. The area began a scoping study for a major initiative across NASA Centers aiding water management across the Western states.

The Health & Air Quality area kicked-off nine projects, spanning infectious diseases, air quality, and environmental health risks. The Air Quality Applied Sciences Team held a meeting in St. Louis with air quality managers to pursue projects applying Earth science to current challenges.

The Ecological Forecasting area reviewed feasibility studies, selecting 10 to continue as full-scale applications projects.

In Wildland Fires, nine projects advanced the use of Earth observations in pre-fire, active, and post-fire management. In 2015, projects were adopted by partners and operational entities, affected Colorado State policy, and were featured in NASA's ScienceCast video series.

The Disasters area projects spanned flooding, volcanoes, earthquakes, and more. The area transformed NASA's approach to its disasters support activities, moving to a preparatory approach with systematic coordination across NASA Centers.

Capacity Building

Our Capacity Building program was extremely effective in 2015. ARSET conducted 11 trainings, reaching more people (2,877) than in the previous six years combined. The trainings reached people in 123 nations and all 50 U.S. states. ARSET introduced trainings for wildfires and conservation, and expanded its work with satellite missions, such as events focused on *SMAP* and *GPM*.

With 393 participants and 93 applications projects, DEVELOP involved all 50 U.S. states and 28 countries across its three terms. DEVELOP had 15 locations and engaged 157 end-user organizations. DEVELOP again held a virtual poster session and contest each term (visit *http://earthzine.org/develop/).*

"NASA's Applied Sciences Program is dedicated to helping public and private organizations apply data from NASA's Earth-observing satellites and related scientific findings in their decision-making activities, to improve the quality of life and strengthen the economy."

Charles Bolden, NASA Administrator

And SERVIR kicked-off its newest hub in Southeast Asia, serving Myanmar, Cambodia, Laos, Thailand, and Vietnam. This hub joined the two other active hubs in Africa and the Himalayan region. Overall, SERVIR reached 43 countries and hundreds of users through projects and trainings. The SERVIR product catalogue, *http://catalogue.servirglobal.net/,* streamlined access to applications, tools, and data, including more than 400 data layers.

Satellite Missions

In 2015, NASA Earth Science launched two missions—the *SMAP* soil moisture satellite and the CATS lidar instrument. Also as planned, NASA decommissioned *TRMM* after 17 highly successful years in space. Unfortunately, *Aquarius* failed after four years in orbit, but the data acquired continue to provide critical information to scientific research.

We again pursued numerous activities to support NASA's Earth science satellite missions, helping introduce users to the satellites, data products, and potential applications. Check them out on pages 16–17.

The *SWOT* and *CYGNSS* missions held their first applications workshops in 2015. *ICESat-2* and *NISAR* conducted user applications workshops, and *GPM* held its first post-launch applications

The Centers for Disease Control and Prevention's Environmental Public Health Tracking Network included *Aura* satellite data for county-level UV exposure information.

NASA included *GPM* satellite information in its support of the flooding response in Texas and surrounding areas, which determined the extent of the event and aided river closure decisions.

The Colorado Basin River Forecast Center used MODIS and VIIRS data to improve its snowmelt and runoff modeling forecasts for the Great Basin.

The U.S. Forest Service integrated *Suomi NPP* satellite data for enhanced wildfire detection and progression predictions, improving its abilities to determine fire boundaries and advance ecosystem restoration.

Colombian ecologists added an additional 70 hectares of habitat for the endangered cotton-top tamarin using Earth observations from *Landsat* and *Terra*.

DEVELOP worked with Thai students on two projects that used *TRMM* and *GPM* observations to assist drought and agriculture monitoring in Thailand.

Our Disasters program area provided rapid support for the Refugio oil spill, which incorporated airborne AVIRIS-NG data and citizen scientists to map the impacts for a quicker, more complete response to the cleanup.

The California Department of Water Resources applied *Landsat*, *Terra*, and *Aqua* satellite observations to gauge changes in farmland and to provide guidance for drought emergency funds.

MODIS data supported alerts to Ohio city and state officials on harmful algal blooms in Lake Erie.

"We're really impressed by the innovative ways our partners are using the data from Earth-observing satellites."

Lawrence Friedl, Applied Sciences Program

meeting. *PACE* formed an applications subgroup, *GRACE-FO* developed a mission applications plan, and *HyspIRI* held its annual science and applications workshop.

The year saw an expansion of the missions' Early Adopters programs, in which organizations evaluate simulated data to help them prepare for actual data after launch. More Early Adopters signed on to *SMAP* and *ICESat-2*, and the *SWOT* and *PACE* missions initiated their Early Adopters programs.

And we actively encouraged the applications community to contribute to the second Earth Science Decadal Survey, which the National Academy of Sciences commenced in 2015 to identify priority directions for Earth science research and applications.

Program Activities

We were extremely active in the international Group on Earth Observations, GEO. We supported major initiatives for water resources, food security, biodiversity, and other topics, including AmeriGEOSS, which improves coordination of Earth observations in the Americas. We organized activities with GEO to bolster uses of Earth observations for the United Nations' 2030 Agenda for Sustainable Development.

For NASA's biennial assessment of Earth-observing satellites, we again organized the National Interests Panel to assess their utility for applied purposes by businesses, governments, and NGOs. We continued our activities to quantify the social and economic benefits of Earth science applications, issuing a solicitation to advance analytic techniques.

We rolled out a new design for our website providing a multimedia approach to information about the program, including project videos and video blogs by the program managers.

And lastly, we had another award-winning year in 2015, including awards for an AQAST member, a video, and our annual report, among others.

2015, In the End

Looking back on the year, we're most proud that hundreds of organizations in the U.S. and abroad applied Earth observations to their activities, and thousands of people learned new ways of using Earth science information.

Observe and Serve

Sometimes the news and views that Earth-observing satellites provide are cheerless and unfortunate, and 2015 had its fair share. In California, the satellites showed the impact of the exceptional drought and the dramatic amount of farming land left fallow due to it, reaching 625,000 acres in 2015. Earth observations also revealed the extent of flooding in the U.S., wildfires in North America, landslides and earthquake damage in Nepal, and scores of other disasters.

In praise of the project teams, they turned the satellites' views of devastation into information for support and recovery. They transformed the bleak perspectives into instruments of compassion and action. A project with the California Department of Water Resources turned analysis of fallowed land into guidance for where California needed to provide social services for underemployed farm laborers. And teams helped Nepalese officials assess landslide potential in the effort to move countless villagers in remote valleys to safer ground.

MMXV IN NUMBERS

2 NEW NASA EARTH-OBSERVING MISSIONS

123 NATIONS INVOLVED IN **ARSET**

7/16 SIGNING DATE FOR NEW **NASA-USDA AGREEMENT**

18 **NUMBER OF NASA** EARTH-OBSERVING SATELLITES

9 NEW HEALTH & AIR QUALITY PROJECTS

65% **APPLIED SCIENCES PROJECTS** ADVANCING AT LEAST ONE ARL

55 **EARLY ADOPTERS** FOR *SMAP* MISSION

8/31 **SERVIR-MEKONG HUB LAUNCH DATE**

93 **DEVELOP** PROJECTS

1:1 **RATIO OF FEMALE TO MALE** DEVELOP PARTICIPANTS

132 **2ND *NISAR* APPLICATIONS** WORKSHOP ATTENDEES

625K **ADDITIONAL FALLOWED ACRES** IN CALIFORNIA BASED ON MODIS AND *LANDSAT* DATA

2,877 PARTICIPANTS TRAINED IN **ARSET**

578 **GLOBAL HAZARD EVENTS** REQUESTING ASTER ACQUISITIONS

15-1129 **COLORADO HOUSE BILL PROMULGATING A** WILDLAND FIRE PREDICTION AND DECISION SUPPORT SYSTEM

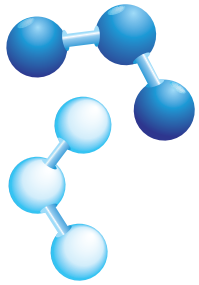
$40.4M APPLIED SCIENCES FY 2015 BUDGET

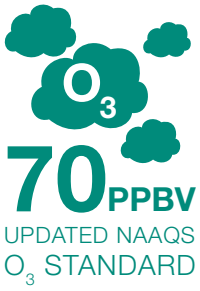
10 COMPANIES ATTENDING THE ***CYGNSS* APPLICATIONS WORKSHOP**

A BREATH OF FRESH AIR

Earth-observing satellites are helping to determine new air quality standards

OZONE





The ABCs of O_3

Ozone, chemically represented as O_3, is a highly reactive gas that can be broadly divided into two categories—"good" and "bad." Good ozone is found in the stratosphere and shields the Earth from harmful levels of ultraviolet radiation; bad ozone is created near the ground level from various natural and human sources, and can have detrimental effects on human health and the environment.

In 2008, the U.S. Environmental Protection Agency (EPA) set bad ozone limits to 75 ppbv (parts per billion by volume) in its National Ambient Air Quality Standards (NAAQS). Since then, updated epidemiological studies have shown there would be better health benefits from lowering it even further.

While EPA considered a reduction, critics asked if some areas of the U.S. could regularly be out of compliance if the bar were set too low, mainly due to high levels of "background ozone."

In turn, Pat Dolwick, a scientist at EPA's Office of Air Quality Planning and Standards, emphasized that the focus was on the well-being of the public. "The primary consideration is what NAAQS level is requisite to protect public health with an adequate margin of safety."

The Background

So what is background ozone? It's the ozone that would normally exist without any human-produced emissions being added to the mix, and it's considered beyond the constraints of regulations. This includes ozone from natural processes, as well as ozone from foreign locations.

The difficulty comes when updating NAAQS policy. Before setting limits on the man-made emissions, EPA wanted to first determine a limit that could be feasible when considering background ozone across the U.S. as a whole… and that can vary widely.

"Background ozone changes from season-to-season, and it's also usually higher in the Western U.S., due to factors such as climate, elevation, wildfire frequency, and ozone transported from locations in Asia," said Daniel Jacob, NASA Air Quality Applied Sciences Team (AQAST) member and professor of atmospheric chemistry and environmental engineering.

Due to previous successful collaborations, EPA reached out again for AQAST's knowledge while the agency determined the suitability of a new standard.

Room for Improvement?

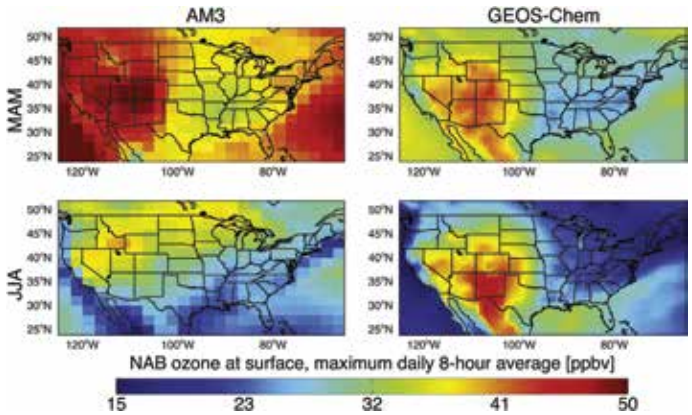
In a joint project with EPA and NOAA, an AQAST Tiger Team first needed to find the errors and uncertainties in the current model estimates of background ozone.

"Satellite data can be very valuable in evaluating the pollutant emissions inputs that are the foundation for most ozone modeling analyses. They can also be useful in assisting the evaluation of ozone model simulations."

Pat Dolwick, U.S. EPA

"Our paper was the first to use two independent global models to estimate background," noted Arlene Fiore, AQAST member and associate professor at Columbia University. Both of those models incorporate Earth observations into their calculations from the Ozone Monitoring Instrument (OMI) and Tropospheric Emission Spectrometer (TES) aboard NASA's *Aura* satellite.

"The [data] retrieved from TES and OMI provide a constraint on free tropospheric ozone, which is the pool of ozone that includes background, that is available to mix down into near-surface air," said Fiore. And despite the seasonal and regional differences across the U.S., the study determined that background ozone alone would not typically push locations over the new standard. "Our work suggested that 70 ppbv should be attainable in most places."



Mean values of North American Background (NAB) ozone in the lowest model layer for the GFDL AM3 and GEOS–Chem. Simulations for spring (MAM; top row) and summer (JJA; bottom row). NAB is estimated with simulations in which North American anthropogenic emissions are set to zero.

New Data, New Standards

AQAST's background ozone results were subsequently included in the updated information comprising EPA's Integrated Science Assessment, and on October 1, 2015, EPA opted to lower the NAAQS standard to 70 ppbv.

"The updated standards will improve public health protection, particularly for at-risk groups including children and older adults," Dolwick said. "They also will improve the health of trees, plants, and ecosystems."

Dolwick stressed the value of the partnership with AQAST, and with Fiore in particular. "Her work has been incorporated in several of our scientific and technical support documents for the proposed ozone standard revisions."

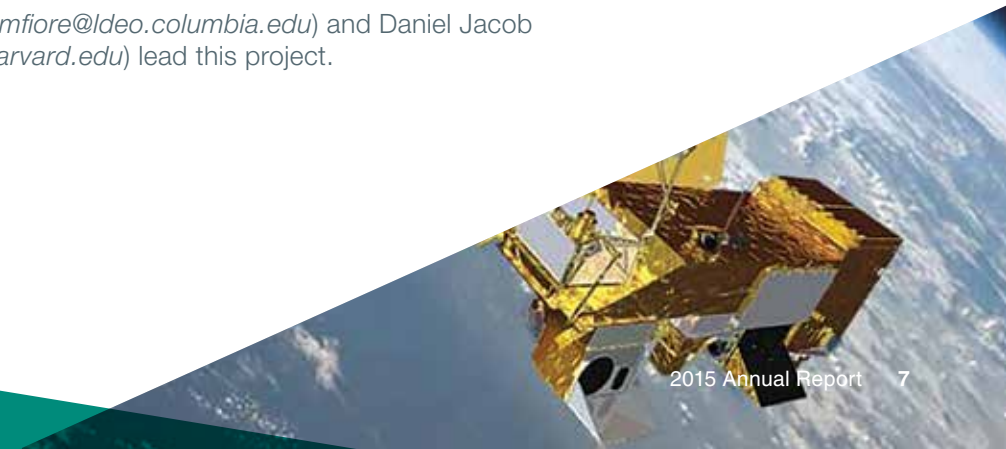
The current success with Earth-observing satellites is already leading to planned NASA missions to provide a new set of tools for background ozone measuring, such as the upcoming TEMPO mission.

Fiore added, "We are trying to extract as much information as possible from existing instruments, while figuring out ways to best utilize the next generation of satellite instruments."

Arlene Fiore (*amfiore@ldeo.columbia.edu*) and Daniel Jacob (*djacob@fas.harvard.edu*) lead this project.

EPA'S EXPECTED ANNUAL HEALTH BENEFITS FROM A LOWER NAAQS:

$2.9–5.9 BILLION



WHEN THE EARTH SHOOK

Data from above guided an unprecedented effort to help Nepal recover from a series of devastating earthquakes

7.8
MAGNITUDE
OF THE NEPAL EARTHQUAKE

The Nepal earthquake disaster launched a global humanitarian effort in 2015. Even as the dust still settled, space-based information aided the nation's recovery… and watched for new hazards.

The Quake

"All of a sudden it seemed like as if the ground had dropped away and then everything around us started shaking… It was impossible to try to stand and escape from there."

Selina Shakya, a native of Kathmandu, was visiting the Nepalese city of Pokhara when the quake struck. "I had experienced a quake before, but not that big where you see buildings falling… and whole districts just vanished into dirt."

A massive 7.8-magnitude temblor, the Gorkha earthquake struck just before noon local time on April 25, 2015, along the boundary where the Indian plate underthrusts the Eurasian plate. Lasting less than a minute, the initial earthquake left approximately 9,000 people dead, with additional quakes and aftershocks continuing for months.

After the Shaking Stopped

Immediately after the Gorkha quake, efforts to assess the damage and start the recovery came from across the globe. David Green, Earth Science's Disasters manager, led the NASA response across our Centers. In a coordinated effort, people began gathering satellite information on the destruction from both domestic and international sources to disseminate to partners that needed it most, such as USAID and USGS, as well as in-country partners like the International Centre for Integrated Mountain Development (ICIMOD), located in Kathmandu. (*www.icimod.org*)

"In a disaster situation like the one Nepal faced, collecting, managing, processing, and disseminating timely and reliable information becomes critical to relief and recovery operations."

David Molden, Director General, ICIMOD

This unprecedented approach tapped many resources including *Landsat* satellites, the *Earth Observing-1* satellite, the Advanced Spaceborne Thermal Emission and Reflection Radiometer instrument aboard NASA's *Terra* satellite, as well as DigitalGlobe satellites and image mosaics. This crucial optical data helped initially determine what regions were damaged or destroyed by the quake, and where to target relief efforts.

Helping this rapid flow of information was ICIMOD's already-established presence in the region. To aid recovery and speed assistance, ICIMOD gave frequent briefings to Nepali government agencies, including the Ministry of Home Affairs. They also provided high-resolution printed images of the quake damage. These paper maps were critical pieces of support as the nation had limited Internet service, which at times delayed the immediate information the nation desperately needed.

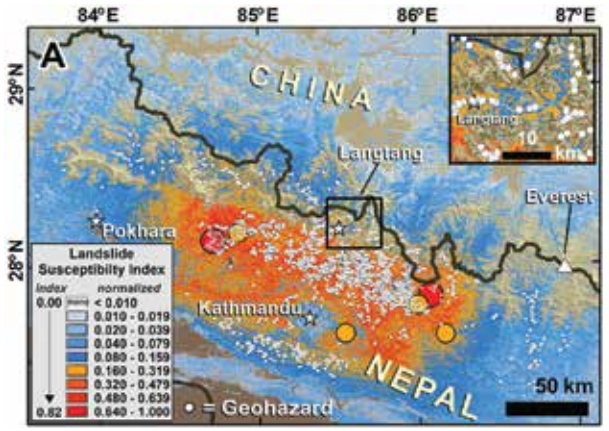
More Threats to Assess

In addition to the initial destruction of the Gorkha earthquake, the region had yet more risks to consider—additional hazards spurred on by the quake and its aftershocks. Those threats included landslides and avalanches, as well as flash flooding caused by blocked rivers and breached glacial lakes.

As a partner in NASA's disaster-relief response, the University of Arizona organized a team of scientists—a volunteer network with people across nine nations—to identify where landslides occurred in earthquake-affected areas of Nepal. In the immediate weeks after the quake, the team used spaceborne and ground observations to collectively map more than 4,300 landslides.

Smaller subgroups of the volunteer network focused on assessing and communicating the disaster, creating damage proxy maps, and producing vulnerability maps that showed potential risks. Jeff Kargel, a glaciologist at the University of Arizona, co-led one subgroup with NASA scientist Dalia Kirschbaum, called the "Induced Hazards" team. This team concentrated on identifying the landslides and other hazards triggered by the quake, as well as guiding relief efforts.

In one instance, a colleague of Kargel's at ICIMOD alerted him in the middle of the night to an urgent situation facing the village of Beni, located at the confluence of the Kali Gandaki and Myagdi Rivers. That village was one of several downstream from where a landslide dam had built a sizeable lake in the river flow. The colleague asked Kargel to use the data he'd collected to provide calculations of downstream flooding if the landslide dam were to break. Within a matter of hours, Kargel relayed that information and authorities evacuated the villages.



Debris landslide susceptibility with mapped hazards (white dots). Susceptibility in units of acceleration divided by g (9.81 m/s²)

4,300+
NUMBER OF
LANDSLIDES MAPPED

As Kargel feared, the landslide dam did give way. “An outburst flood roughly matching my numbers washed away one village and came lapping up onto Beni,” he said. “Nobody was killed, though one small village was destroyed.”

A Long Path to Recovery

In the months following the earthquake, the volunteer network knew more hazards were still potentially ahead. Aftershocks still jolted the region, and the monsoon season was coming. With the ground already unstable from the quake, the likelihood of landslides would be much higher when the rains came.

The team shared its mountains of data with ICIMOD, which in turn advised the Nepali Prime Minister and his cabinet of the new hazards they faced. “The briefing was well received,” said Kargel, who added that it opened the government’s eyes to the “uses of remote sensing in the earthquake response.”

As the relief efforts continued, Selina Shakya remained optimistic: “My hope for my country is to rise again and with everybody’s great effort we will build our nation even better. I know it might take us a very long time… but I haven't seen the people of Nepal losing their hopes. They are tirelessly working to reach out to people in need.”

More than 75 people and organizations contributed to NASA’s response to the Gorkha earthquake and associated hazards.

9
NATIONS IN THE
NEPAL QUAKE
VOLUNTEER NETWORK

BIDDING FOR THE BENEFIT OF BIRDS

Space-based technology and compassionate citizens are aiding waterfowl conservation

What's a long-billed dowitcher worth? How about a spotted sandpiper? For some rice farmers in California's Central Valley, renting out a priceless avian oasis is bringing both economic benefits and ecological rewards.

300+ BIRD SPECIES USE THE PACIFIC FLYWAY

The Pacific Flyway—An Avian Interstate

During their annual migration, more than 300 species of birds are estimated to use the Pacific Flyway as their connection between the Arctic and South America. Along this plumed pipeline lays the Central Valley of California, a flat valley stretching more than 650 kilometers through the middle of the state, and its wetlands are ideal for waterbirds to rest, feed, and winter. In fact, it's believed that the Central Valley hosts up to 60 percent of the total Flyway population in some years.

Less Room

In the last 150 years, things like flood control efforts, agricultural irrigation, and a booming Golden State population have left migrating waterbirds with much less stopover space than before.

What's more, the high real estate values of the region mean that conservation projects such as property easements and land purchases are prohibitively expensive since these birds stay only brief periods of time during the year.

Trying to tackle this hurdle, The Nature Conservancy (TNC) of California stepped in. Mark Reynolds, the lead scientist for TNC's California Migratory Bird Program, knew it would be a challenge. "How do you help things that move around and create habitat in places that may only be important for a few weeks or a few months out of the year?"

Before TNC could find a solution, it needed some data.

Eyes in the Sky and on the Ground

Enter eBird—a mobile application the Cornell Lab of Ornithology developed that asks avid birders to record bird sightings on a smartphone app and send the information to its database. Since its inception, eBird has logged 200 million bird observations—the largest biodiversity dataset in existence. Through a grant from our Program, the lab developed a computer-modeling system using eBird data combined with data from the *Landsat*, *Aqua*, and *Terra* satellites. These data and tools can predict the locations in the Central Valley that would be the most popular watering holes during the annual spring and fall migrations.

"Data from NASA satellites formed the basis of powerful predictive models of where and when birds needed habitat most, allowing us to develop efficient and cost-effective wildlife habitat programs with California farmers."

Mark Reynolds, The Nature Conservancy

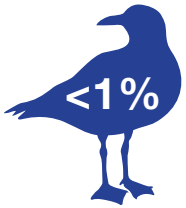
200 MILLION

BIRD OBSERVATIONS LOGGED WITH eBird

TNC also wanted to discern where it had gaps in the data for where the much-needed, temporary wetlands could be located. For this it turned to TNC partner Matthew Reiter, an ecologist for the conservation group Point Blue, who had been using *Landsat* observations to determine where the potential wetlands were in the Central Valley.

"The real value of the satellite… archive is that we're able to look at the water distribution at a very fine spatial scale… which is really relevant in terms of understanding habitat for migratory waterbirds," said Reiter.

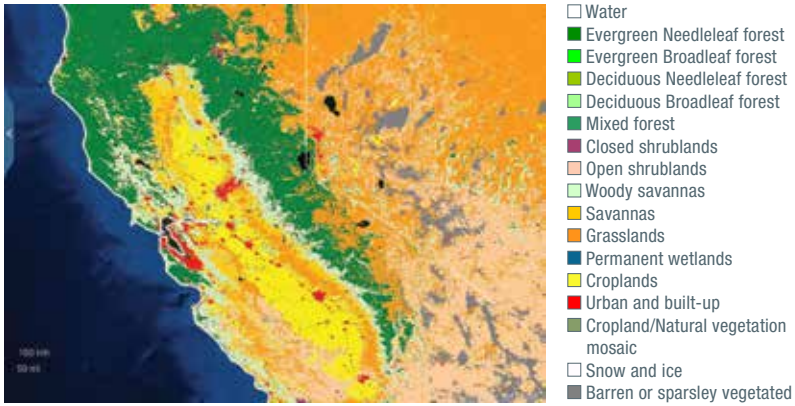
Matching the geography and timing of surface water with the route and seasonality of migrating waterbirds from eBird, the research found key locations where extra surface water would provide perfect havens for the birds. In an effort to secure these "pop-up habitats," TNC developed its BirdReturns program which relies on rice farmers to flood their fields for a two-week period during prime migratory season through a reverse auction.



TEMPORARY HABITAT COSTS **LESS THAN ONE PERCENT** OF THE PRICE FOR PURCHASING CONSERVATION LAND.

"Going Twice, Going Once…"

How does a reverse auction work? First, rice farmers submit their bids for how much they would like to be paid for allowing their fields to temporarily remain idle by shallowly flooding them. Then TNC collects the most reasonable bids and selects the fields with the most desirable bird habitat, based on the eBird and Point Blue analysis. TNC then pays farmers to keep their fields flooded during critical migration times in the spring and fall.



Land cover in California from MODIS satellite data

Model showing the probability of spotting a least sandpiper overlaid with the probability of available surface water

For the rice farmers, the financial reward is their compensation for the potential liability they face by delaying field preparations for next season's planting. "By holding our water, we're taking a risk," said Doug Thomas, a participating farmer in the Sacramento Valley. "Everything that goes along with that has to be factored into your economic equation."

This novel method of renting temporary wetlands allows TNC to provide Flyway habitat for less than one percent of the cost of purchasing conservation easements. What's more, the farmland is idle only during bird migration, and can produce rice at any other time of the year.

Astonishing Results

During its initial season, the BirdReturns program was an immediate success—approximately 10,000 acres of additional wetlands were acquired. For control purposes, the project group surveyed those participating fields and compared them to fields where water wasn't applied. It found that more than 180,000 waterbirds comprising more than 50 different species used the temporary wetlands—30 times more than were counted on the dry fields.

Follow-up auctions continued to see rice farmers renting thousands more acres, with a cumulative total of about 30,000 acres of temporary wetlands gained by the end of 2015.

"It's been a pretty astonishing success," said Mark Reynolds. "Farmers participated, and we were able to put habitat out there at a fraction of the cost to purchase that land or put an easement on it."

Steve Kelling (*stk2@cornell.edu*) leads this project.

30,000 ACRES
OF TEMPORARY WETLANDS GAINED

TAMING THE INFERNO

A pioneering system is using satellites to expedite wildfire recovery—while the fires still rage

It was born from a lightning bolt. In less than a week, it grew into the largest ongoing wildfire in the United States.

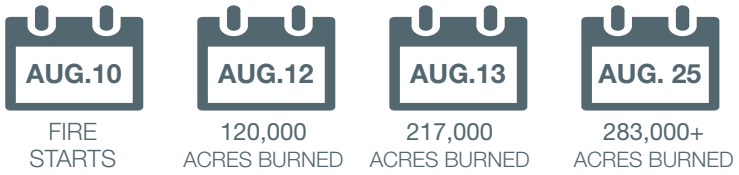
An Insatiable Appetite

The Soda Fire ignited on August 10, 2015, burning across the rugged landscape of southwest Idaho and eastern Oregon. Feeding on sagebrush, cheatgrass, and mountain mahogany, the blaze expanded quickly, from 78,000 acres on the morning of August 12, to 120,000 acres by that afternoon.

When Keith Weber, director of the Idaho State University (ISU) GIS Training and Research Center, heard about the fire's quick growth that day, he knew what lay ahead. Through his team's partnership with the Bureau of Land Management's (BLM) Boise District, their work to facilitate the use of satellite data for post-fire rehabilitation had become part of active fire-fighting efforts.

"The fire was an unusual one," Weber remarked. "One of those rapidly moving mega-fires that can be very problematic."

His assessment proved right. By the next morning, the wildfire had exploded to more than 210,000 acres.



A Request for Data

During this rapid expansion, the BLM reached out to Keith Weber for the information it needed immediately—near real-time data on the fire's extent and recent impacts. That information is critical for the BLM's Emergency Stabilization and Rehabilitation team, which must quickly assess the fire's damage, as well as determine areas that require rapid treatment and restoration.

Access to this information was now possible thanks to a beneficial mapping system that Weber helped develop called the Rehabilitation Capability Convergence for Ecosystem Recovery (RECOVER).

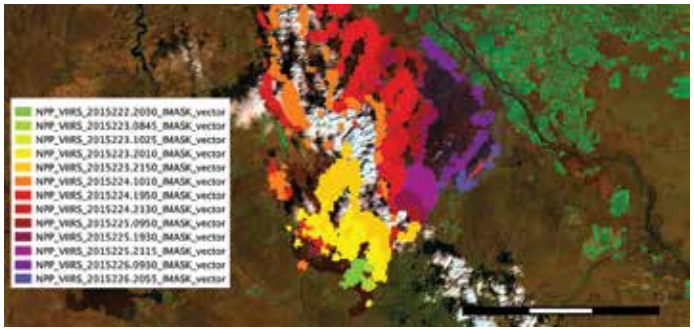
"The land management agencies were doing all the work to fight the fire," said Weber. "What we were doing was supporting them so they could make good decisions quickly about how to fight the fire, and later, how to manage the land after the fire."

"RECOVER makes available all geospatial data relevant to a wildfire in five minutes. That includes a collection of NASA Earth-observing satellite imagery and derived products… Now that is truly awesome."

Keith Weber, Idaho State University

The Big Picture

In partnership, ISU, BLM, and NASA built RECOVER to establish a novel way of providing information for rapid remediation during and after wildfires using already-existing satellite data. It does this by creating a single tool that automatically integrates a multitude of data and imagery layers, such as current and archived *Terra*-MODIS imagery, *Landsat* imagery, and *Suomi NPP*'s Visible Infrared Imaging Radiometer Suite (VIIRS) instrument data. The RECOVER system then assembles and superimposes the information on top of imagery of burned and burning areas to produce near-real time updates in an easy-to-use interface accessible on a standard Web browser.



An August 14, 2015, *Landsat 8* image of the Soda Fire burn perimeter with VIIRS fire pixel vectors showing accumulated fire data

By gathering up to 20 different datasets, like wildlife habitat and local topography, RECOVER helps BLM rehabilitation crews assess the situation more completely and quickly. Before this, remediation crews would have had to wait for the fire to be contained first, and then complete an assessment before submitting a rehabilitation plan. The assessment would include surveying multiple websites for information on soil layers, plant species composition, burn severity mapping, and other data, according to Gregory Mann, a fire ecologist with the BLM.

That process of collecting information was typically challenging and time-consuming—often taking several days to more than a week to complete. "When we're dealing with large fires, it's extremely difficult," Mann added.

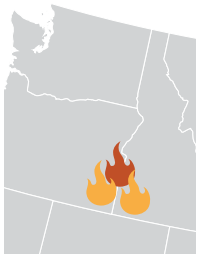
From Days to Minutes

The massive Soda Fire ultimately burned more than 283,000 acres across the Northwest. Thanks to RECOVER, crews were able to automatically generate and refresh derived data while the fire was still actively burning—something that wasn't possible before.

In fact, by the time the wildfire was contained, crews already had a complete and ready-to-use customized analysis of the Soda Fire. With that data at their fingertips in a matter of five minutes, the teams could promptly determine where to target their rehabilitation efforts.

"RECOVER supported our early rapid assessment for rehabbing after the fire even while firefighters were still on the ground," Karen Miranda, information officer for the Emergency Stabilization and Rehabilitation team, said. "Pre-planning before the fire is fully contained helps our work move forward as quickly as possible."

Keith Weber (*webekeit@isu.edu*) leads this project.



283,000+
ACRES BURNED
IN THE SODA FIRE

HOW QUICKLY
RECOVER
PROVIDES WILDFIRE
RESPONSE DATA

TIMELINE 2015: A YEAR IN APPLIED SCIENCES EVENTS

14–18 MARCH

Third UN World Conference on Disaster Risk Reduction; Sendai, Japan: More than 6,500 delegates from 187 nations, including more than 25 Heads of State, Vice Presidents, and Heads of Government, attended the conference. Our Disasters program area led NASA's presence at the conference, including a U.S. event showing Earth observations research and applications. NASA contributed to the formulation of the Sendai Framework, which included references to satellite observations and supported a risk information and knowledge sharing strategy.

JANUARY

- **4–8** American Meteorological Society Annual Meeting; Phoenix
- **6–8** ESIP Winter Meeting: Earth Science and Data in Support of Food Resilience: Climate, Energy, Water Nexus; Washington, D.C.
- **10** Launch of CATS instrument to ISS; Cape Canaveral Air Force Station, Florida (see page 26)
- **14** Climate Policy Speaker: "Windfall: The Booming Business of Climate Change," McKenzie Funk; NASA Headquarters, Washington, D.C.
- **26** DEVELOP: Start of 2015 Spring Term: 114 participants and 29 projects
- **27–29** National Council for Science and the Environment: Energy and Climate Change Conference; Arlington, Va.
- **31** Launch of *SMAP* satellite; Vandenberg Air Force Base, California (see page 26)

FEBRUARY

- **10–12** Wildland Fires Team Meeting; Salt Lake City
- **14** Release of NASA Research Opportunities in Space and Earth Sciences solicitation
- **16–20** SERVIR: Water Resources Workshop; Islamabad, Pakistan

MARCH

- **3–4** Water Resources Applications Area Team Meeting; College Park, Md.
- **10–11** 2nd *ICESat-2* Applications Workshop; NASA GSFC, Greenbelt, Md.
- **10–11** GEOGLAM and AgMip Joint Workshop; USDA-Agricultural Research Service, Beltsville, Md.
- **12** Capacity Building: Strategic Planning Workshop; NASA Headquarters, Washington, D.C.
- **14–18** 3rd UN World Conference on Disaster Risk Reduction; Sendai, Japan
- **17** ARSET: Start of Webinar Series on Introduction to *Global Precipitation Measurement* (*GPM*) Data and Applications
- **23–27** CEOS Workshop on SRTM Data & Flood Modelling; Pretoria, South Africa
- **24–26** Climate Prediction Applications Science Workshop: Drought Information for Food Resilience, Agriculture, and Water Resources; Las Cruces, N.M.
- **30** ESD: Applied Sciences Advisory Committee meeting; via teleconference
- **31** ARSET: Start of Webinar Series on Introduction to Remote Sensing for Wildfire Applications

APRIL

- **1** ARSET: Start of Webinar Series on NASA Earth Observations and Tools for Air Quality Applications in Southeast Asia
- **3** DEVELOP: End of Spring Term
- **12–17** World Water Forum; Daegu and Gyeonbuk, South Korea
- **18–22** GEO Water Quality Summit; Geneva, Switzerland
- **20–24** Wildland Fire Safety Summit; Boise, Idaho
- **21** Association of American Geographers Annual Meeting; Chicago
- **22** Earth Day
- **22** United Nations Event on the Sustainable Development Goals: Unleashing the Power of "Where"; New York City
- **25** Gorkha earthquake and start of major disaster response support; Nepal
- **28–30** ESD: Senior Review National Interests Panel; Washington, D.C.

1 MAY–31 OCTOBER

Expo 2015; Milan, Italy: The 2015 World Expo had the theme of Feeding the Planet, Energy for Life. The USA Pavilion invited NASA to participate in the Expo. Applied Sciences Director Lawrence Friedl spoke there on May 16th about uses of Earth observations for food security. Other NASA speakers at the USA Pavilion included Administrator Charles Bolden and Chief Scientist Ellen Stofan.

MAY

- **4** DEVELOP: Spring Virtual Poster Session (VPS) winner announced
- **5** ARSET: Start of Webinar Series on Introduction to Remote Sensing for Conservation Management
- **5–7** GEO Work Plan Symposium; Geneva, Switzerland
- **11–15** 36th International Symposium on Remote Sensing of Environment; Berlin, Germany
- **13** GEOGLAM Early Warning Crop Monitor Meeting; UN Food and Agricultural Organization, Rome, Italy
- **15–20** American Thoracic Society 2015 International Conference; Denver
- **16** World Expo 2015: NASA Earth Science talk at USA Pavilion on Earth Observations for Food Security; Milan, Italy
- **19–22** ARSET: Training with Disasters on Climate Variability, Hydrology, and Flooding; Cartagena, Colombia
- **24** Disasters: Collection of AVIRIS-NG data for Refugio Oil Spill; Santa Barbara, Calif.
- **27–29** *CYGNSS* Applications Workshop; Silver Spring, Md.
- **28–29** SERVIR-West Africa Planning Meeting; Niamey, Niger
- **31–9** AMS Summer Policy Colloquium; Washington, D.C.

JUNE

- **1** DEVELOP: Start of 2015 Summer Term: 174 participants and 38 projects
- **2–4** Air Quality Applied Sciences Team Meeting; St. Louis
- **3–5** *HyspIRI* Mission & Products Symposium; Greenbelt, Md.
- **8** ARSET: Start of Webinar Series on NASA Remote Sensing Observations for Flood Management
- **8–11** The Norwegian "Oil on Water" spill exercise deploys the NASA/UAVSAR for the first time
- **9–10** *GPM* Applications Workshop; College Park, Md.
- **15** *TRMM* satellite re-enters the Earth's atmosphere after a successful 17-year mission (see page 27)
- **16–18** International Workshop on Greenhouse Gas measurement from Space; Pasadena, Calif.
- **16–19** GEO-CAPE Applications Town Hall meeting, International Ocean Colour Science Conference; San Francisco
- **17–19** GEO BON Joint Advisory Board and Implementation Committee Meeting; Leipzig, Germany
- **22–2** International Union of Geodesy and Geophysics; Prague, Czech Republic
- **22–25** Air & Waste Management Association's Annual Conference; Raleigh, N.C.
- **23–25** Globalizing Societal Application of Scientific Research and Observations from Remote Sensing workshop; Tacoma, Wash.
- **29–30** Pivotal 2015 International Executive Summit; Brisbane, Australia

JULY

7–9 *Landsat* Science Team Meeting; USGS Earth Resources Observation and Science Center, South Dakota.

13–16 NCAR/CDC Workshop on Climate and Health; Boulder, Colo.

13–17 Precipitation Measurement Mission Science Team Meeting; Baltimore

16 NASA and USDA Sign Interagency Agreement; NASA ARC, Moffett Field, Calif.

20 Esri User Conference; San Diego

26–31 IEEE International Geoscience and Remote Sensing Symposium; Milan, Italy

28–29 Gorkha Earthquake Response Lessons-learned Workshop; NASA JPL, Pasadena, Calif.

30 2015 DEVELOP Earth Science Applications Showcase; NASA Headquarters, Washington, D.C.

30 Tropical Cyclone Komen: Provided Myanmar government with requested satellite data on flooding

AUGUST

2–6 International Congress for Conservation Biology; Montpellier, France

7 DEVELOP: End of Summer Term

10–11 Geospatial Media and Communications GeoBuiz Summit; Bethesda, Md.

18–20 WHO Global Platform on Air Quality and Health; Geneva, Switzerland

25–27 Climate Science to Engineering Operations for Watershed Management Workshop; Seattle

28 DEVELOP: Summer VPS winner announced

31 SERVIR: NASA and USAID launch SERVIR hub for Lower Mekong River Basin serving Southeast Asia

31– 2 GEO-CAPE Community Workshop; Research Triangle Park, N.C.

SEPTEMBER

1–3 ARSET: Training with Air Quality on NASA Air Quality Remote Sensing Training for SESARM & GEPD; Atlanta

1–4 SERVIR: Global Exchange Symposium; Bangkok, Thailand

6–10 Keynote, European Congress on Tropical Medicine and International Health; Basel, Switzerland

14 DEVELOP: Start of 2015 Fall Term: 105 participants and 26 projects

15–17 International Workshop on Evapotranspiration Mapping for Water Security; World Bank, Washington, D.C.

16 Water Cycle Frontiers and Western Water Mission workshop; NASA JPL, Pasadena, Calif.

16–17 Health and Air Quality Applications Area Team Meeting; Park City, Utah

17 SERVIR: NASA-USAID Town Hall; Washington, D.C.

17 Earth Venture Mission 2 Bidders Conference; via teleconference

21–24 SPIE Remote Sensing Conference; Toulouse, France

28–29 Disasters: Agency-wide Disaster Response Plan Workshop; NASA MSFC, Huntsville, Alabama

OCTOBER

1 ARSET: Start of Advanced Webinar Series on Satellite Remote Sensing of Particulate Matter Air Quality

2 SERVIR: Release of SERVIR Applied Sciences Team solicitation

6–8 ARSET: Wildfire Applications Workshop; Idaho State University, Pocatello, Idaho (see pages 24-25)

12–16 6th International Wildland Fire Conference; Pyeongchang, Gangwon, South Korea

13–15 *NISAR* Mission Applications Workshop; NASA ARC, Moffett Field, Calif.

13–15 *HysplRI* Science and Applications Workshop; California Institute of Technology

20 Land and Atmosphere Near real-time Capability for EOS (LANCE) User Working Group Meeting; NASA GSFC, Greenbelt, Md.

29 Climate Policy Speaker: "Climate Change and the Paris Climate Summit: The Oxfam Perspective," Heather Coleman; NASA Headquarters, Washington, D.C.

NOVEMBER

1–4 Geological Society of America Annual Meeting; Baltimore

6 SHORE: A Research Symposium for Students, Scientists and the Community; Daytona Beach, Fla.

8–12 Coastal & Estuarine Research Foundation Biennial Conference; Portland, Ore.

9–12 GEO-XII Plenary and Side Events; Mexico City, Mexico

13 GEO Ministerial Summit; Mexico City, Mexico

14 Announcement of award for Voice for Whales video from the Television, Internet & Video Association of DC

16–19 AWRA Water Resources Conference; Denver

16–20 Regional Media Training Workshop: Air pollution, its sources and impacts, and mitigation options; ICIMOD, Kathmandu, Nepal

16–20 International Fire Ecology & Management Congress; San Antonio

17–19 *NISAR* Science and Applications Workshop at ISRO Space Applications Centre; Ahmedabad, India

20 DEVELOP: End of Fall Term

21 *EO-1* satellite celebrates its 15th year in orbit

30 ARSET: Special Webinar on NASA Applied Remote Sensing Trainings on Water Quality Monitoring Using Remote Sensing Observations

DECEMBER

2–3 AMS Policy Program: From Innovation to Societal Benefit Workshop; Washington, D.C.

7 Applied Sciences: Release of Socioeconomic Benefits solicitation

11 Health and Air Quality: Release of H&AQ Applied Sciences Team solicitation

14–18 American Geophysical Union Fall Meeting; San Francisco

16 *Ignite@AGU* Event; San Francisco

23–25 JUNE

Globalizing Societal Applications Workshop; Tacoma, Wash.: We sponsored a workshop to outline paths toward global capacity building. Experts from the applied sciences community and international stakeholder agencies came together to discuss capacity building using Earth observations, along with ways to connect science and research with societal applications.

9–13 NOVEMBER

GEO GROUP ON EARTH OBSERVATIONS

GEO-XII Plenary and Ministerial Summit, Mexico City, Mexico: The Group on Earth Observations (GEO) held its 12th Plenary Session and a Ministerial Summit to adopt a new strategy and work program to advance international coordination on the collection, sharing, and uses of Earth observations for societal benefits. We organized and moderated numerous side events during the week, including ones on AmeriGEOSS, a new GEO water initiative, and one on the U.N. Sustainable Development Goals. (See pages 30–32)

DEVELOP: VIRTUAL POSTER SESSION AWARD WINNERS

Spring
"Beyond a Shadow of a Drought: Remote Monitoring in the Navajo Nation"

Summer
"There's Not a Lot of Ocelots: The Search for an Endangered Feline"

Fall
"A Changing Landscape: Monitoring Cheatgrass with Satellite Imagery"

http://earthzine.org/develop/

WATER FOR LIFE

Earth observations are helping countries manage their water security

90%
OF PAKISTAN'S AGRICULTURE IS DEPENDENT UPON **GROUNDWATER**

50%
OF PAKISTAN'S LABOR FORCE IS DEPENDENT UPON **AGRICULTURE**

A Vast and Vital Resource

The largest contiguous irrigation system on Earth, the Indus Basin provides water to 100 million people across South Asia. This basin is estimated to irrigate 45 million acres of farm land, and it's considered the bread basket of Pakistan—essential for sustaining the agriculture and economy of the nation.

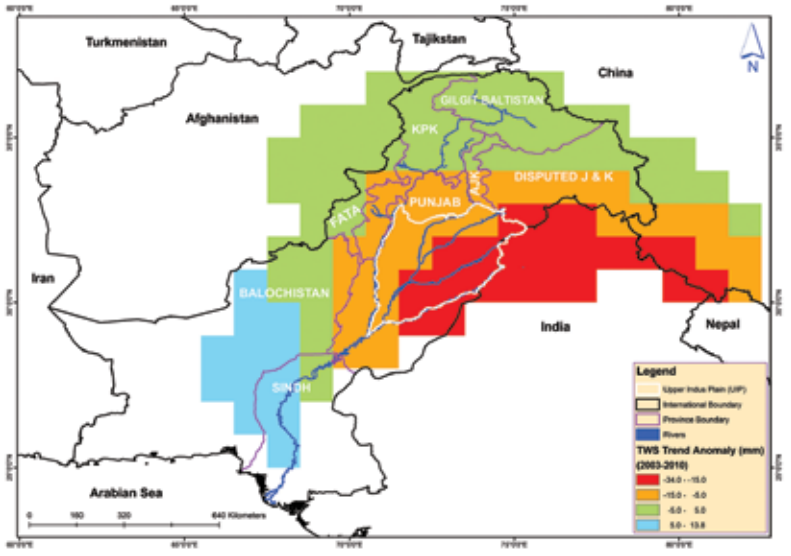
Until recently, monitoring the amount and location of available irrigation water could be a large undertaking of both labor and equipment. "Data were being collected manually, on a bi-annual basis... the collection, organization, and analysis of the data were time consuming and a tedious job," noted Ashraf Muhammad, chairman of the Pakistan Council of Research in Water Resources (PCRWR).

A Passion and Purpose

Enter Earth-observing satellites. Now, that enormous task is being expedited and enhanced with help from space, thanks to PCRWR, other South Asian government agencies, and an Applied Sciences project.

Faisal Hossain, associate professor at the University of Washington, led this project with both passion and purpose. "I'm originally from Bangladesh, so my heart is in the South Asian region," said Hossain. "It was pretty clear to me that a lot of [the information] NASA satellites provide, somehow people didn't really know about... It didn't make sense not to use these observational capabilities."

These space-based views included information from the *Gravity Recovery and Climate Experiment* (*GRACE*) mission to help monitor groundwater storage, as well as rainfall data from the *Global Precipitation Measurement* satellite. The project also developed and implemented a land-surface water model to give Pakistan the opportunity to look at its future water supply.



Mean trend of Total Water Storage anomalies from 2003–2010 over Indus Basin of Pakistan. Courtesy PCRWR

"*GRACE*-based data is readily available, free, can be applied at a large scale such as the Indus basin, and is reliable. Moreover, there are no data sharing issues as compared to traditional datasets."

Ashraf Muhammad, PCRWR

And in a novel approach, the project team used a fast-track way of making the nation self-sufficient with this new data.

GRACE and Diplomacy

After meeting a bright and motivated PCRWR hydrologist named Naveed Iqbal at a *GRACE* training workshop, the project team wanted to try a new way of teaching Earth observation applications—which they dubbed their "backward-forward hybrid training model." In this model, Hossain invited Iqbal to the University of Washington to attend a long-term satellite "boot camp."

Iqbal jumped at the chance. "This training was an excellent opportunity to learn about the different applications of Earth observation technology for water resource management," he said. "It was a great experience to work with experts."

Hossain added, "He spent six months learning in a very intense laboratory residency framework on how *GRACE* works and how to process satellite data. We are finding this training model to be not only more effective, but also cost-effective."

And when Iqbal had completed the course, he brought both his newfound knowledge and its uses back to his homeland and PCRWR.

The Flow of Information

Since Iqbal's training, Pakistan has taken charge of its own water management—performing duties such as monitoring ground water storage, regulating ground water pumping, and augmenting surface water supplies.

With groundwater now monitored on a monthly basis, Muhammad emphasized the benefits of this new technology. "*GRACE* has empowered us to analyze the spatial and temporal variations of the groundwater system at the basin scale. Now, PCRWR is in a good position to play its advisory role."

Iqbal agreed, and explained, "Using these satellites, we can indicate the areas that are most threatened by groundwater depletion. We can tell the farmers and help decision-makers formulate better and more sustainable policies."

The project team hopes to help other countries in the region become self-sufficient as the project continues and expands. "Ideally, we would love to see all the South Asian water management agencies be able to control their water management destiny," Hossain remarked, "And that can happen through these wonderful Earth-observing satellites and data which are made freely available."

Faisal Hossain (*fhossain@uw.edu*) leads this project.

NASA, WE NEED YOUR HELP

Earth observations are aiding the mission to end river blindness

120 MILLION
PEOPLE AT RISK FROM RIVER BLINDNESS WORLD-WIDE

14 YEARS
HOW LONG THE RIVER BLINDNESS WORM CAN LIVE IN THE HUMAN BODY

When a former president of the United States asked for assistance in eliminating a debilitating disease from the Americas, it was a challenge we decided to take on.

Scourge of Millions

"My daughters must cook my meals, clean the house, and help me dress."

That is how river blindness changed Pitasia Gonzales of rural Mexico. She acquired the disease many years ago and it not only took her sight, it also stole her independence.

River blindness, or onchocerciasis, is an affliction caused by a parasitic worm that's transmitted person-to-person by the bites of *Simulium* sp. black flies. It gets its more common name due to the fly's breeding grounds along fast-flowing rivers and streams, as well as the disease's tendency to cause vision loss for its sufferers, among other debilitating symptoms.

Since its inception, The Carter Center's Onchocerciasis Elimination Program for the Americas has had one goal—ending the disease in North and South America. The program works with six afflicted nations in the Americas administering safe and effective ivermectin tablets (Mectizan®, donated by Merck) in afflicted communities. Through determined work by the ministries of health of these countries, the transmission of river blindness has ended in Gonzales' native Mexico, as well as in Colombia, Ecuador, and Guatemala.

As of 2015, the threat from river blindness in the Americas remained only in the dense rainforest area along the Venezuela and Brazil border, where the native Yanomami people live.

The Letter

President Jimmy Carter made his mission for 2015 clear: "By the end of this year, all river blindness-affected Yanomami communities need to be identified so we can begin to provide villages with medicine and health education."

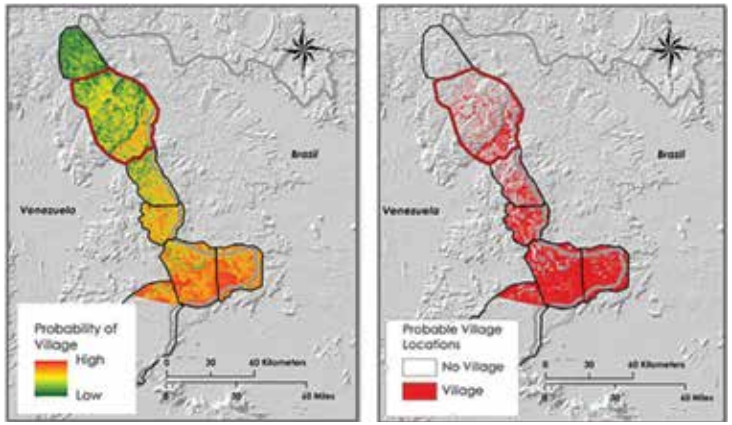
Then came the letter. Addressed to NASA Administrator Charles Bolden, it was a request from President Carter to help Venezuela locate any remaining unidentified villages in the deep Amazon rainforest.

President Carter had personally visited the Yanomami before and knew how difficult it was to find these villages. And NASA, with its 'eyes in the sky' imagery, was ready to help provide the new information to locate villages that were not yet registered by the health system.

Still, it wouldn't be easy, and making the task more difficult was the fact that the Yanomami migrate frequently due to shifting land suitability and food supplies. They also tend to remain close to rivers—prime habitat for the black fly.

"Thanks to NASA's work, we are able to feel more confident that the country is truly tracking down any possible last vestiges of river blindness in this exciting elimination effort."

Frank Richards, The Carter Center



Probable Yanomami village locations determined by a DEVELOP suitability model

Scanning the Amazon

NASA's Applied Science DEVELOP program, with its flexibility and expertise, took on this project. Using Earth observations from *Landsat* and ASTER, along with data provided by the National Geospatial-Intelligence Agency, three DEVELOP teams collaborated on a project to help The Carter Center with its mission.

The result was an interactive map with latitude/longitude coordinates, associated imagery, and approximate populations (based on hut roof areas) for all potential Yanomami villages that were identified. For areas where there were questionable settlements, the team created a suitability model that identified areas where the Yanomami would likely inhabit.

The End in Sight

In total, the project team found evidence of more than 160 potential villages, generally identifiable by their shabono, which are open, oval huts constructed in rainforest clearings. Many of these were anticipated to overlap with the known 460 endemic Yanomami communities; however, the assumption was that some would be new to the system. The team presented its information and methods, which included an interactive map in Google Earth, to The Carter Center in August 2015.

The following month, The Center shared this new information with the Venezuelan river blindness health workers, who later determined that 16 of the villages discovered were previously unknown to them. Subsequent fly-overs of four of those villages in 2015 confirmed that they were inhabited. One was visited on foot, and determined to be non-endemic for river-blindness. Venezuela intends to visit all the newly discovered villages in 2016.

"We are thrilled with the results of this project. And even for the villages that are ultimately found not to be endemic for river blindness, the country will now be able to offer other needed health services where they were previously unavailable," said Frank Richards, director of The Carter Center River Blindness Elimination Program.

As this mission continues, The Carter Center is driven to give the Yanomami what it gave to Pitasia Gonzales—hope for the future. After her grandchildren received preventative treatment from The Center, Gonzales was optimistic. "Their generation has the opportunity to preserve its vision."

Michael Ruiz (*michael.l.ruiz@nasa.gov*) leads our DEVELOP program.

YANOMAMI PEOPLE'S RANGE, INDICATED **IN BLUE ABOVE**

RIVER BLINDNESS IS THE WORLD'S **FOURTH LEADING** CAUSE OF PREVENTABLE BLINDNESS

WEATHERING UNCERTAINTY

A joint effort to keep Eastern Africa fed

100 MILLION
POPULATION OF ETHIOPIA

MAIZE
EASTERN AFRICA'S MOST IMPORTANT CEREAL CROP

When life and livelihood depend upon the rain, the whim of weather creates a precarious relationship between farmer and Mother Nature.

Finding a Remedy

"Flooding and drought… are challenging issues in Ethiopia."

As a scientist at the Ethiopian Institute of Agriculture Research, Degefie Tibebe has seen the effects that meteorological mood swings can have on his nation's welfare. "In 2015… El Niño triggered water shortages and crop failures in large parts of the country. It left almost one-fifth of Ethiopians needing food aid."

Ethiopia was not alone. The climate pattern parched much of Eastern Africa, a region where agriculture is nearly one-third of the GDP.

So how do you help stabilize the teetering food security of a region where almost all of the crops are highly dependent on rain?

That question was the focus behind our project that aimed to make Eastern Africa more resilient to the wet and dry cycles of weather by using readily-available data from Earth-observing satellites.

Mapping the Future

Denis Macharia (RCMRD/SERVIR) conducting a field survey in the Nzoia Basin

The result, the culmination of a multi-year partnership the International Research Institute, the Climate Change, Agriculture and Food Security Initiative, and our SERVIR program was RHEAS—the Regional Hydrologic Extremes Assessment System.

RHEAS is breaking new ground in sub-Saharan farming by integrating data from *Aqua*'s Advanced Microwave Scanning Radiometer-EOS, the *Soil Moisture Active Passive* mission, and other satellites

"RHEAS helps to expand the spatial domain, benefiting farmers across the country by informing them how to increase productivity, manage weather-induced risks, and improve food security."

Degefie Tibebe, Ethiopian Institute of Agriculture Research

and sensors, into water and crop forecasts. RHEAS can estimate and predict such factors as seasonal conditions, vegetation health, and expected crop yield, as well as drought onset, severity, and duration.

Marking a major milestone, RHEAS became open source in 2015. The Nairobi-based organization and SERVIR partner, the Regional Center for Mapping of Resources for Development (RCMRD), helped to transfer and disseminate the RHEAS data to the Ministries of Agriculture in six countries of Eastern Africa, including Tibebe's homeland of Ethiopia. People can map the information to provide detailed forecasts in the form of very short-term "nowcasts" (0-6 hours), as well as seasonal outlooks and long-term projections.

This new visual information was vital for the region, yet it came with obstacles. A major one was, how do you reach local agricultural officials so they can access, interpret, and use this new information?

Cultivating Knowledge

In a word—outreach. Project partners organized national workshops with local government personnel in five participating countries.

Eager to learn the applications of this new system, Tibebe attended the workshop in Ethiopia. "We were very impressed," he said, "RHEAS integrates satellite products to simulate extreme events. Drought is one of the extreme events that affects Ethiopia repeatedly."

These workshops also gave attendees the chance to provide valuable feedback on how to tailor the RHEAS project to meet specific needs, such as working with local ministries and extension agents to ensure that maps are in a readily useable and timely format.

One solution? Making forecast maps accessible via the Web, which provides information to decision-makers more quickly and easily.

With the increasing prevalence of extreme weather events in Eastern Africa, Tibebe explained the importance of having the RHEAS system in place. "About a century ago, the frequency of drought occurrence in Ethiopia was once every 10 years. However… it is now occurring once every five years, or even less."

Dan Irwin (*Daniel.E.Irwin@nasa.gov*) leads our SERVIR program.

COUNTRIES
USING RHEAS DATA

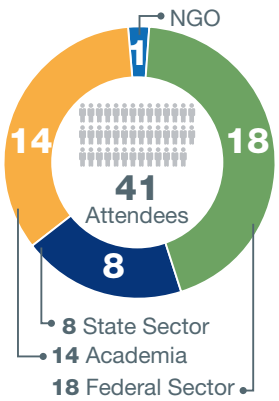
30%

AGRICULTURE'S SHARE
OF THE GDP IN EASTERN AFRICA

SPARKING A MOVEMENT

Spreading satellite-based strategies for wildland fire management

ARSET 2015 WILDFIRE WORKSHOP



U.S. PUBLIC LAND MANAGED BY THE BLM

How do you get valuable, space-based wildfire information into the hands of people who can use it the most? One way is to bring the science down to Earth in a hands-on, real-world setting.

Assistance from Above

"To me, the potential for these Earth-observing systems is tremendous… but in many cases, untapped."

As director of the GIS Training and Research Center at Idaho State University (ISU) and lead on an Applied Sciences project, Keith Weber has seen the successes of incorporating near real-time Earth observations into U.S. fire remediation. In fact, he was called upon to deliver that critical information during the massive Soda Fire in August 2015. (See pages 14–15)

Weber was convinced that integrating satellite data was going to be revolutionary for wildfire management, yet he also knew its current limitations. "It was not because the wildfire community did not want the information, but rather many were unaware of the availability or how to access these data."

The Call to Collaborate

His pursuit led to ARSET's first-ever dedicated wildfire applications training, with the goal of expanding efforts to bring this cutting-edge technology to responders and applied researchers. Weber's outreach brought together a network of partners from across the wildfire community, including land managers, university faculty, and the U.S. Forest Service's Remote Sensing Applications Center.

ARSET workshop attendees at the post-Charlotte Fire burn site, October 2015

More than 180 organizations participated in the first component of the training, which was a 5-week introductory webinar. The instruction focused on the benefits of spaceborne Earth observations, such as *Landsat 8*, *Suomi NPP*, and *SMAP* data, to get the "big picture" data of wildland fires—information like landscape vegetation, terrain topography, and soil moisture.

How to apply this new information came in part two of the training—an on-site workshop at ISU.

10 MILLION+

NUMBER OF ACRES IN THE U.S. SCORCHED BY WILDLAND FIRES IN 2015

Mark Fitch, with the National Park Service (NPS) Fire Management Program, attended the workshop hoping to learn how Earth observations might aid wildfire smoke management, especially at night. "We currently have night flight missions that use infrared to help estimate the smoke signature, which is used to advise responders and warn the public," he said. "Satellite data would help with this as the night missions are dangerous and can be costly."

Scars of the Charlotte Fire

To highlight a real-world case in the workshop, members of the Idaho Bureau of Land Management (BLM) led a tour of a burn site from the Charlotte Fire of 2012. The blaze devastated parts of southeastern Idaho as it roared across 1,000 acres of cedar and sagebrush, incinerating more than 60 homes. Even three years later the impacts of the fire on the vegetation were still apparent.

"It was a very hot, fast moving fire, so it essentially burned everything to the ground," said Cindy Schmidt, an ARSET land management team leader who organized the webinar and visited the burn scar. She noted that, "invasive plant species were popping up in many areas that had been disturbed by the wildfire." As Mark Fitch and the others toured the area, he remarked on the site's progress since the fire. "It was most interesting to see the success of the re-seeding treatment."

For Keith Weber, the outreach effort produced exactly what he hoped for—the alliance of two previously disconnected groups. "It was not the science community teaching the fire community, or vice versa, but rather the two communities coming together to tackle wildfire management."

Ana Prados (*Ana.I.Prados@nasa.gov*) leads our ARSET program.

"The smoke community needs to incorporate more remote sensing in their work."

Mark Fitch, NPS Fire Management Program

NEW YEAR, NEW LAUNCHES

SMAP

NASA launched the *Soil Moisture Active Passive* (*SMAP*) satellite in January 2015. Through two primary instruments (a radar and a radiometer), *SMAP* measures and maps global soil moisture and its freeze/thaw state every two-to-three days. *SMAP* also observes variations over time scales ranging from major storms to repeated measurements of changes over the seasons.

In July, the radar instrument unfortunately failed due to an anomaly involving its high-power amplifier. The radiometer instrument continued to perform well, and the mission continued to produce high-quality science measurements supporting *SMAP*'s objectives. The *SMAP* mission reached 55 Early Adopters, which accelerate applications of the data and provide feedback on data products from users to increase the mission's overall value.

CATS

In January, NASA launched the Cloud-Aerosol Transport System (CATS) instrument to the International Space Station. CATS uses its Light Detection And Ranging (lidar) system to measure the location, composition, and distribution of pollution, dust, smoke, aerosols, and other atmospheric particulates through the diurnal cycle.

CATS data support scientific research on the atmospheric constituents that impact global climate, which allows scientists to create better models of the Earth's feedback processes. The mission extends the global lidar data record for the continuity of climate observations. The data also support a variety of applied purposes, including improving air quality forecasts and health risk alerts.

UPCOMING MISSIONS TO THE ISS

2016

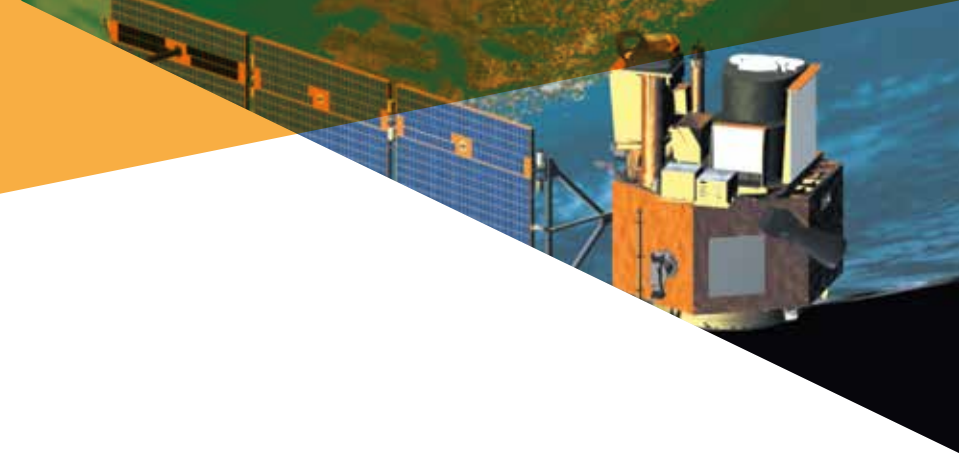
SAGE III

2018

GEDI
ECOSTRESS
OCO-3
TSIS-1

Happy Anniversary, *EO-1*!

Celebrating a milestone in 2015, the *EO-1* satellite had its 15th year in orbit.



PAYING RESPECTS

TRMM

As planned, NASA decommissioned the *TRMM* (*Tropical Rainfall Measuring Mission*) satellite after more than 17 years in orbit. *TRMM* re-entered Earth's atmosphere without incident over the South Indian Ocean in June, 2015. *TRMM* was a joint NASA/JAXA satellite mission that carried the first precipitation radar flown in space, enabling scientists to see the internal structure of storms for the first time.

TRMM was a pioneer in demonstrating the breadth and value of applications of Earth-observing satellite data, creating a legacy of new applications for societal benefit. *TRMM* data supported tropical cyclone forecasting, flood detection, as well as drought and disease monitoring.

TRMM data helped forecasters at the National Hurricane Center and the WMO predict tropical storm intensification, and the USDA Foreign Agricultural Service also routinely used its near-real-time global precipitation data to monitor crop conditions around the world.

Applications and research supported by *TRMM* continue with the *GPM* satellite launched in 2014.

Aquarius

In June, the *Aquarius* satellite failed after four years in orbit. The mission was an international Earth-observing mission partnership between NASA and Argentina's space agency for measuring sea surface salinity. With the first global salinity measurements from space, *Aquarius*' measurements helped in tracking the formation and movement of water masses that regulate ocean circulation and climate.

NOAA's CoastWatch program used *Aquarius* data to generate daily and weekly composites of salinity measurements, and the U.S. Integrated Ocean Observing System monitored ocean chemistry with *Aquarius*.

Fortunately the mission successfully achieved its scientific objectives and completed its primary three-year mission in November 2014. Knowledge derived from *Aquarius* continues to help with the understanding of ocean dynamics and the advancement of climate models, including El Niño prediction.

YEARS OF
RAINFALL DATA
COLLECTED BY *TRMM*

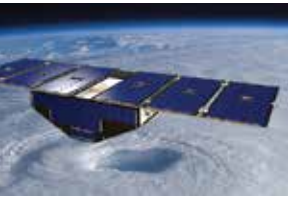
AMOUNT OF
SALT *AQUARIUS*
COULD DETECT IN A
GALLON OF WATER

"*TRMM* has been the world's foremost satellite for the study of precipitation and climate processes in the tropics, and an invaluable resource for tropical cyclone research and operations."

Scott Braun, NASA Goddard Space Flight Center

APPLICATIONS AND SATELLITE MISSIONS

ICESat-2



CYGNSS

GPM

The *Global Precipitation Measurement* (*GPM*) satellite is a joint NASA/JAXA mission to provide next-generation observations of rain and snow worldwide every three hours. In *GPM*'s second year in orbit, we held a *GPM* applications workshop in June to inform attendees about the mission and discuss its applications, including a special ARSET training and thematic sessions on public health, agricultural monitoring, and disasters, among others.

CYGNSS

The first Earth Venture satellite mission, *Cyclone Global Navigation Satellite System* (*CYGNSS*), will study the formation and intensification of hurricanes. We held the first *CYGNSS* applications workshop in May 2015 as a bridge between the research and applications communities. Discussions focused on terrestrial, oceanographic, and modeling and forecasting applications. Launch is planned for 2016.

GRACE Follow-On

The *Gravity Recovery and Climate Experiment* Follow-On (*GRACE-FO*) mission entered its design and development phase in 2015. The mission will detect very small variations in the Earth's gravitational field, which can measure changes in groundwater and aquifers. We continued to promote its applications at numerous events, including the 2015 Climate Prediction Applications Science Workshop. The mission is on track for a 2017 launch.

ICESat-2

The *Ice, Cloud, and land Elevation Satellite-2* (*ICESat-2*) mission will offer global measurements of surface elevation and multi-year observations of ice-sheet elevation change, sea ice above-water height, and vegetation canopy height. In 2015, the applications team held its second applications workshop and issued calls for new Early Adopters, adding five. *ICESat-2* is scheduled for launch in 2018.

ECOSTRESS

The ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS) sensor will launch to the ISS in 2018. The mission will address critical questions on plant-water dynamics on a diurnal cycle as well as how ecosystems change with climate. In 2015, the ECOSTRESS team developed simulated data products for its operational partners.

SWOT

With an expected launch in 2021, the *Surface Water and Ocean Topography* (*SWOT*) satellite mission will monitor the Earth's surface water and hydrologic cycle. In 2015, the *SWOT* Applications Working Group began its Early Adopter program, held its first user applications workshop, and attended the American Water Resources Association annual meeting. The mission is joint with France's Centre National d'Études Spatiales with contributions from the Canadian Space Agency.

"*Jason-3*, much like its predecessor *Jason-2*, will be able to measure the height of the ocean in an area that is about 6 miles across, from 800 miles [altitude], with an accuracy of about one inch, so about the width of a quarter."

Josh Willis, NASA Jet Propulsion Laboratory

NISAR

The planned *NASA-ISRO Synthetic Aperture Radar* (*NISAR*) mission will use radar to observe ecosystem disturbances, ice-sheets, and natural hazards such as earthquakes and landslides. The joint mission, a collaboration between NASA and the Indian Space Research Organization (ISRO), held its second applications workshops in 2015, which focused on developing the suite of products and software needed to support the applied science community. The *NISAR* launch is planned for 2021.

TEMPO

The Tropospheric Emissions: Monitoring of Pollution (TEMPO) sensor is planned to fly in geostationary orbit and monitor major air pollutants hourly across North America during the daytime. As the first Earth Venture Instrument mission, TEMPO held its third Science Team Meeting in 2015, and the first applications workshop will occur in July 2016. The mission is scheduled for launch in 2021.

PACE

The *Pre-Aerosol, Clouds, and ocean Ecosystem* (*PACE*) mission will make global ocean color measurements relevant to ocean ecology and aquatic carbon storage, along with measurements of clouds and aerosols. At the first *PACE* Science Team meeting, team members formed an applications subgroup, which identified specific application concepts relevant to the mission, including the monitoring of fire and smoke, air quality, and harmful algal blooms.

HyspIRI

The *Hyperspectral Infrared Imager* (*HyspIRI*) satellite is a proposed mission that will study the world's ecosystems, measure vegetation health, and provide critical information on natural disasters, such as wildfires and volcanoes. Activities in 2015 included the *HyspIRI* Science and Applications Workshop and the *HyspIRI* Science Symposium. The mission group provided the keynote speaker at the 2015 European Congress on Tropical Medicine and International Health.

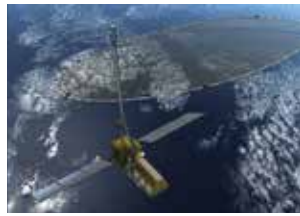
Looking Up… and Counting Down

NASA plans to launch three Earth-observing science missions in 2016:

The *Jason-3* mission will be the fourth in a U.S.-European series of satellite missions that measure the height of the ocean surface.

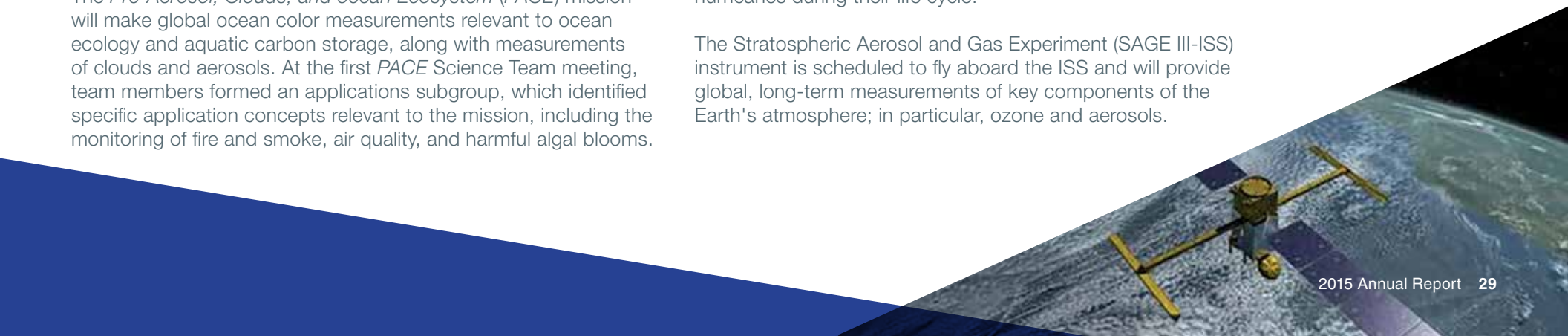
The *CYGNSS* Earth Venture mission will blast off using a constellation of eight small satellites to measure ocean surface winds in and near the eyes of tropical cyclones, typhoons, and hurricanes during their life cycle.

The Stratospheric Aerosol and Gas Experiment (SAGE III-ISS) instrument is scheduled to fly aboard the ISS and will provide global, long-term measurements of key components of the Earth's atmosphere; in particular, ozone and aerosols.



NISAR

HyspIRI



GROUP ON EARTH OBSERVATIONS

Continuing international leadership and service to humanity

102
MEMBERS IN
2015

5
NEW GEO MEMBERS
IN 2015

Engage. Advocate. Deliver.

These actions drive the second decade of the international Group on Earth Observations, GEO. In 2015, government ministers adopted a new GEO strategic plan for 2016–2025 to implement a vision in which Earth observations inform decisions and actions for the benefit of humankind.

As lead of the U.S. delegation to the 2015 GEO Summit, Secretary of Interior Sally Jewell joined other high-ranking officials to endorse a Ministerial Declaration, highlighting the strategic value of GEO's convening power and the social and economic importance of full and open access to data. Among several initiatives, their refreshingly succinct declaration called on GEO to leverage Earth observations to support the sustainable development goals.

Throughout 2015, NASA Earth science continued its active participation with GEO and U.S. contributions. We directly supported major initiatives in GEO on data use and coordination for water resources, food security, biodiversity, and other topics.

GEO: 2016–2025

A new strategic plan for its second decade lays out the strategy and key means to implement its goals. The plan presents eight thematic areas and a new categorization of activities, allowing projects of different scale, type, and maturity. Adding organizational rigor to GEO, a new program board examines the scope and substance of proposed activities with GEO priorities and resources.

8 SOCIETAL BENEFIT AREAS

- Disaster Resilience
- Health Surveillance
- Food Security and Sustainable Agriculture
- Biodiversity and Ecosystem Conservation
- Water Resources Management
- Urban Resilience
- Energy and Natural Resources Management
- Infrastructure and Transportation Management

GEOGLAM

The GEO Global Agricultural Monitoring, GEOGLAM, initiative enhances international capacity to monitor crop production with Earth observations for improving food security and market stability. In 2015, GEOGLAM continued providing publicly available analyses each month on unified global production assessments. The team

“Countries have borders; Earth observations don't.”

Barbara Ryan, Secretariat Director, GEO

made major developments on an Early Warning Crop Monitor, which it plans to release in 2016. GEOGLAM also convened its first advisory meeting, which includes the World Food Program and the Bill and Melinda Gates Foundation.

GEO BON

The GEO Biodiversity Observation Network, GEO BON, serves the acquisition, coordination, and delivery of observations of biodiversity and ecosystem services across marine, freshwater, and terrestrial ecosystems. In 2015, GEO BON launched BON in a Box, a toolkit to set up a biodiversity observation network. A side event at the GEO Summit highlighted six new global biodiversity change indicators that support tracking Convention on Biological Diversity targets. Ecological Forecasting program manager Woody Turner continued his service on the GEO BON Advisory Board, co-authoring a paper on how remotely-sensed Essential Biodiversity Variables can best be described.

AmeriGEOSS

At the 2015 Summit, GEO launched AmeriGEOSS, which is a framework to promote collaboration and coordination among the GEO member countries in North, Central, and South America. This initiative focuses on Earth observations and its uses for agriculture and food security, disaster risk reduction, water resource management, and biodiversity and ecosystem monitoring. Capacity Building program manager Nancy Searby and her colleagues across agencies and countries worked tirelessly on its development. They presented AmeriGEOSS to the GEO audience, and the Ministerial Declaration referenced it by name.

GEOGLOWS

GEO also launched the GEO Global Water Sustainability initiative, GEOGLOWS, which provides a common context for projects and activities, and supports development of terrestrial water information systems. GEOGLOWS includes components of global water sustainable development, essential water variable understanding, and water basin risk minimization. GEO approved the GEOGLOWS strategy, which Water Resources program manager Brad Doorn and his colleagues developed.

2016 Observations

Our work with GEO will continue and build in 2016. We'll be heavily involved with the GEOGLOWS global water activity and the AmeriGEOSS initiative as those begin in earnest. GEO BON looks to expand BON in a Box, and GEOGLAM looks to launch its Early Warning Crop Monitor to serve countries at risk. We will begin our leadership on the GEO initiative for the sustainable development goals, and we will expand our work with GEO’s capacity building, disasters, and health activities.

The Group on Earth Observations is an intergovernmental organization working to improve the availability, access, and use of Earth observations to benefit society. With 102 member governments and 95 participating organizations in 2015, GEO organizes efforts to coordinate observations from thousands of ground, airborne, in situ, and space-based instruments. GEO focuses on Earth observations for societal benefit areas, such as water, health, disasters, and agriculture.

PARTICIPATING ORGANIZATIONS **IN GEO**

YEAR **GEO** WAS **ESTABLISHED**

SUSTAINABLE DEVELOPMENT GOALS

17
SUSTAINABLE DEVELOPMENT GOALS

169
TARGETS

What do 17 and 169 have to do with 2015 (or 2030 for that matter)? A whole lot if you're living on Earth.

These are the number of sustainable development goals and targets that the United Nations General Assembly adopted in September 2015, to guide a 15-year global development agenda.

These so-called "SDGs" address everything from hunger, sanitation, poverty, energy, economic growth, disease, fresh water, disasters, air quality, biodiversity, hygiene, and deforestation, to name a few…

All of these happen on Earth—which is why we see the Goals and Targets as a key opportunity for Earth science. They're another way for Earth observations to contribute to the economic, social, and environmental benefits that the Goals represent.

On Earth Day 2015, we were invited guests at the United Nations on this topic. We presented at an event introducing UN diplomats, staff, and others to Earth observations and how they can help countries and stakeholders achieve the SDGs.

Our efforts support the Group on Earth Observations, or GEO, which is actively involved with roles for Earth observations and the SDGs. The Ministerial Declaration issued by GEO in November 2015 recognized the roles that Earth observations can play, and it specifically called on GEO to launch an initiative on this topic. To kick things off, we helped develop and hosted a side event at the annual GEO Plenary meeting. And, we signed on as a co-lead for the GEO Initiative (aka GI-18), so we'll be busy with that in 2016 and beyond.

Our work on this topic is national, in addition to international. In particular, we'll work closely with national statistical offices, such as the Census Bureau, to blend Earth observations and numerical data to support U.S. planning, tracking, and reporting on the Goals.

For more information, visit *www.un.org/sustainabledevelopment/*

For the GEO Plenary Side Event, visit:
http://earthobservations.org/me_sevent.php?seid=439

EARTH SATELLITES IN THE NATIONAL INTEREST

When it comes to serving national interests, what's the utility of NASA's current fleet of Earth-observing satellites? That's the question we helped NASA address in 2015.

You see, every two years NASA Earth Science evaluates the satellites that are beyond their design life. In this "Senior Review" process, NASA determines which satellite missions to continue and which ones to conclude. In addition to the research value, extension costs, and technical health of the satellite, the Senior Review also considers the satellite mission's service to national interests.

That's where we come in.

In 2015, Applied Sciences was once again in charge of the National Interests Panel (NIP) within the 2015 Senior Review. Sixteen organizations accepted our invitation to assess each mission's support to business, public services, policy making, military operations, and other non-research purposes. The panel judged the overall utility of each satellite based on its value, frequency of use, and latency. The size and representation on this panel has grown considerably since the first one in 2007, and the 2015 NIP was the largest ever.

How many satellites did they assess in 2015?

Ten: *Aqua*, *Aquarius*, *Aura*, *CALIPSO*, *CloudSat*, *EO-1*, *GRACE*, *Jason-2/OSTM*, *SORCE*, and *Terra*.

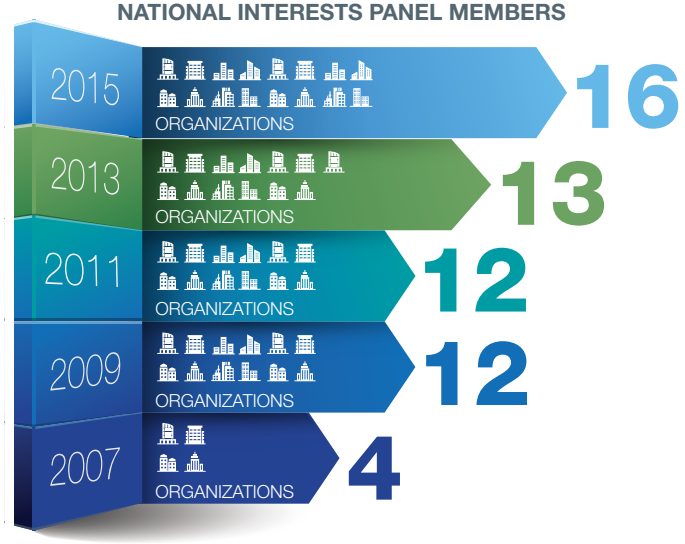
The NIP found that *Aqua* and *Terra* had very high utility, seven satellites had high utility, and *EO-1* had some utility. Combined with the other mission factors, the Senior Review committee recommended to continue all the satellites except for *EO-1*, which they recommended for close-out.

NASA satellites making critical contributions to NASA's research objectives and national interests? That's out of this world.

Applied Sciences' program managers John Haynes and David Green organized and chaired the NIP.

See the 2015 report here: *http://science.nasa.gov/earth-science/missions/operating.*

NATIONAL INTERESTS PANEL MEMBERS



Our thanks to the National Interests Panel:

CDC, EPA, USGS, USDA, FAA, NOAA/NWS, NOAA/NOS, DHS/FEMA, NSGIC, URISA, U.S. Army Corps of Engineers, U.S. Geospatial Intelligence Foundation, Naval Research Laboratory, Conservation International, International Association of Wildland Fire, Alliance for Earth Observations

AWARDS AND RECOGNITION

Kudos and Credit

The NASA Earth Science Applied Sciences Program's 2014 digital annual report won the 2015 Silver W³ Award from the Academy of Interactive & Visual Arts. The W³ Award honors superior creativity on the Web.

Esri president Jack Dangermond presents award to ICIMOD's Basanta Shrestha and Sudip Pradhan

The SERVIR-Himalaya host organization ICIMOD earned the Esri Humanitarian GIS Award for its contribution to the Nepalese government's disaster response efforts following the 2015 earthquakes in the country.

In May, Mary Ellen Miller, principal investigator in our Wildland Fires program area, received the Best Oral Presentation Award at the 36th International Symposium on Remote Sensing of Environment.

Amber Soja receives the Best Presentation Award at the 6th International Wildland Fire conference

Our Wildland Fire program's associate program manager Amber Soja and her colleagues won Best Presentation at the 6th International Wildland Fire Conference. This work highlights decades of fire research and the importance of fire-relevant NASA data to climate systems, as well as the application of these data.

A study we supported, and led by the Earth System Science Interdisciplinary Center's Huan Wu and Bob Adler, won the Editor's Choice Award of the AGU journal, Water Resources Research. The paper describes and validates the group's Global Flood Monitoring System.

NASA AQAST member Anne M. Thompson received the 2015 Roger Revelle Medal at the AGU Fall Meeting Honors Ceremony. The medal recognized "outstanding contributions in atmospheric sciences, atmosphere-ocean coupling, atmosphere-land coupling, biogeochemical cycles, climate, or related aspects of the Earth system."

Our video, "A Voice for Whales: Using Satellite Data to Protect Marine Mammals," garnered an award from the Television, Internet & Video Association of DC. The WhaleWatch project, supported by the Program, uses NASA satellite data to predict the occurrence of whales off the West Coast of the United States. (*https://www.youtube.com/watch?v=v9lyJUE4MgQ*)

"Building on a solid year, we're enthusiastic about continuing our progress in 2016 and beyond."

Lawrence Friedl, Applied Sciences Program

LOOKING AHEAD

We're proud of our successes in 2015, and we're energized for the new opportunities ahead. Each of our elements is set to have a very productive year in 2016, and the Program overall has some new items it's introducing.

In Capacity Building, ARSET will conduct our first training sessions on health applications. SERVIR opens a new hub in West Africa and will select people for our follow-on SERVIR Applied Sciences Team. And DEVELOP will conduct special projects with the National Park Service to help celebrate NPS's centennial year.

We'll start a lot of new projects in our applications areas. The Water Resources, Disasters, and Ecological Forecasting areas will run competitive solicitations for applications projects, including a call for special studies on ecosystem services. Health & Air Quality will select people for its follow-on applied sciences team, and will include a health focus in addition to air quality.

We'll launch a new center focused on developing applications for water management in the Western U.S. And, for our food security initiative, we'll solicit and select an organizational consortium to engage user organizations and develop applications.

Satellite Mission Planning

We'll continue our support to enhance the benefits of upcoming Earth-observing satellite missions through involvement of applications users. *SMAP* will hold its fourth applications workshop. *SWOT* and *ICESat-2* will solicit new Early Adopters. *GRACE-FO* will begin implementation of its Applications Plans, including an outreach workshop. *PACE* will have applications areas presented at the Ocean Sciences Meeting in February 2016, and *HyspIRI* will again hold a data product symposium as well as a research and applications workshop.

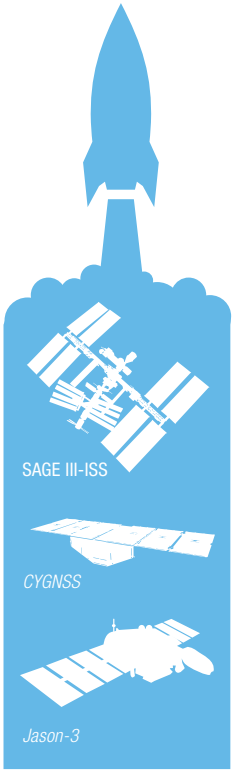
Several satellites and missions join NASA's Earth science fleet in 2016. NASA will launch the *Jason-3* satellite, deploy the SAGE-III instrument to the International Space Station, and launch a constellation of small satellites in the first Earth Venture mission *CYGNSS*.

Program Activities

Our work with GEO will carry on and likely grow in the new year. Our efforts to quantify the socioeconomic benefits of Earth science applications will expand as well. We'll conduct a March workshop on valuation methods and begin several impact analyses on Water Resources and Health & Air Quality projects. We will also select a team to organize a program of activities to advance analytic techniques and help the Earth science community learn about key economic terms and concepts.

These are just some items ahead for us in 2016—there are even more that we don't have space for here. As always, we'll continue to pursue effective ways for organizations to use Earth science data and knowledge to improve their decisions and actions.

To learn more about how Earth science serves society, visit *http://AppliedSciences.NASA.gov.*



LOOKING UP IN 2016

APPLIED SCIENCES

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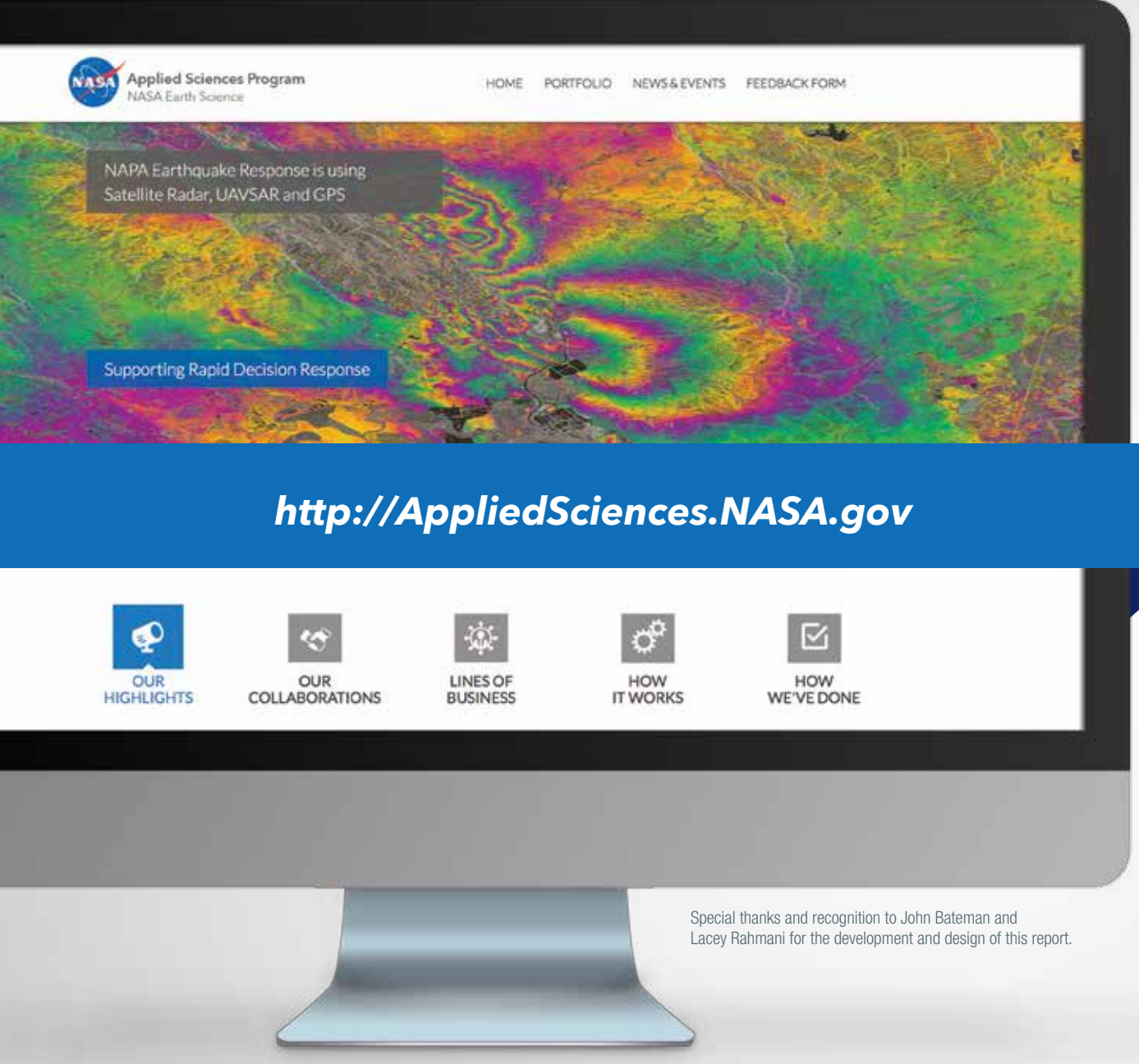
Studies and Analysis
Booz Allen Hamilton support

Capacity Building Elements

ARSET (Applied Remote Sensing Training) builds skills in accessing and using Earth observations data across applications topics through computer-based training for commercial, non-profit, and government professionals.

DEVELOP is a national training and development program for individuals to gain experience applying Earth observations through 10-week interdisciplinary projects, with state and local governments.

SERVIR is a NASA-USAID venture that fosters applications of Earth observations to help developing countries assess environmental conditions and climate change to improve their planning and actions.



Our website has a new look...

NASA Earth Science
Applied Sciences Program

Earth Science. Applied.

Special thanks and recognition to John Bateman and
Lacey Rahmani for the development and design of this report.

NASA Earth Science
Applied Sciences Program

http://AppliedSciences.NASA.gov

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NP-2016-04-2152-HQ